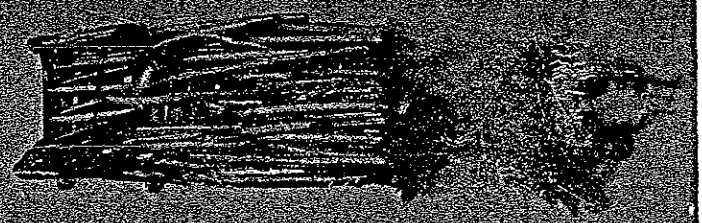


E-Z-EM®

Service Manual

RESPIRONICS®

Windows 95 Calibration Set-Up

Click on START
Click on PROGRAMS
Click on ACCESSORIES
Double Click on HYPERTERM
The screen will ask for a NAME: Give it anything you wish
You will get a PHONE NUMBER screen, go to a window called CONNECT USING
Select COM1
Hit OK
PROT Settings:
Bitts – 1200
Data Bits – 8
Parity – None
Stop Bits – 1
Flow Control – X on/X off
Select the ADVANCED screen
Turn OFF the FIFO Buffer

Turn on the PLV-102
Status line should appear
Put keyboard in CAPS LOCK and type CALIB

NT Set-up

In the "Properties" screen select "Connect to" and select COM 1
Click the "Configure" button:
You will now have a "Port Settings" screen
- **Bits per sec = 1200**
- **Data Bits = 8**
- **Parity = None**
- **Stop Bit = 1**
- **Flow Control = X on/X off**

Click OK
Select the "Settings" screen
- **Function, arrow, and ctrl keys act as:**
  - **Terminal Keys**
- **Emulation**
  - **TTY**
- **Backscroll Buffer lines:**
  - **500**

Click OK
Turn on the PLV-102
Status line should appear
Put keyboard in CAPS LOCK and type CALIB

#1 HAVE ENVALVE CONNECTED (SMALL LINE ONLY) #5 WEIGHT TO 10 EACH WAY

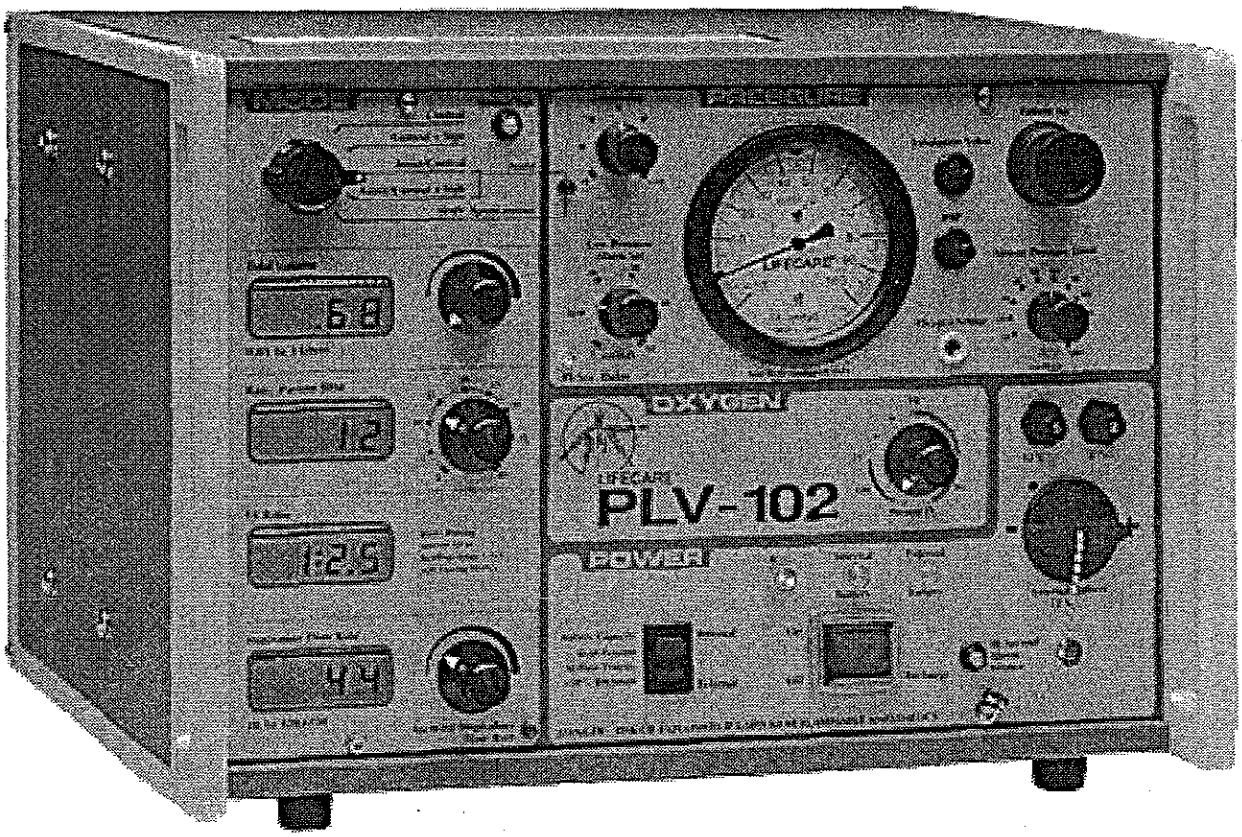
FOR ALL TESTS.

RESPIRONICS®

SERVICE MANUAL

PLV-102
37505

* DUMP VALVE DUMPS AT 115 REGUARDLESS OF FRONT PANEL SETTING & PCB VOLTAGES CHANGE WITH KNOB CHANGE – ✓ TO220 IRF520 ON P.S. PCB



©Respironics 1998

SIGH EVERY 100 BREATHS

3 MODES ON 100 - 5 MODES ON 102

O_2 SENSOR ONLY ACTIVE IN SIMV MODE (50 PSI O_2 SOURCE)

OLD UNITS HAVE ENTERNAL REGULATOR

* 102 SHOWS ERROR CODES IN FLOW WINDOW

MOST COMMON ERROR A-4 O_2 ALARM SET TO HIGH OR LOW O_2 PRESSURE

* 102 DOES NOT MIX O_2 IN THE CYLINDER

REAR PRINTER PORT NOT A TRUE RS232 PORT (IF NO COMMUNICATION CHK CAPS ON THAT 232)

RECAL FOR ABOVE 3200'

ONLY DELIVERS O_2 WHEN BREATH IS BEING DELIVERED

BAD 5 VOLTS REPLACE BULKHEAD HEAT SINK ASY.

IF UNIT SQUEEKS ON INHALE & EXHALE ↓ MOTOR CONTROL WHEEL (POSITION IT TOWARDS MOTOR)

IF VOLUME PROBLEM REPLACE OPTO ASY.

IF "CLUNK" SOUND WHEN PISTON STARTS AT EITHER END - TIGHTEN SCREWS ON BOTH CHOKES ON PWR PCB

* CAL SOFTWARE IS IN THE EPROM
* VALUES ARE IN THE NOV RAM

ALARM CODES IN 102 WINDOW (FLOW WINDOW)

* 200 SEGMENTS IN 102 ENCODER

PTRIM & VTRIM IMMEDIATELY STORED IN 102 (NO NEED TO TURN OFF)

* BLANK WINDOW DURING SIMV MODE (I:E WINDOW)

Respironics Colorado, Inc.
1401 W. 122nd Avenue
Westminster, CO 80234-3421 USA
800/669-9234
Customer Service: 800/345-6443
FAX: 800/886-0245

Respironics Deutschland GmbH
Gewerberstrasse 17
D-82211 Herrsching Germany
49/8152-93060
FAX: 49/8152-930618

INSPATORY IS ONLY TIME O_2 FLOWS

Section 1.0 Introduction 9
- About this Manual
- Servicing and Warranty
- Service Location
- Service and Inspection Forms
- Recommended Service, Repair, and Test Equipment
- Engineering Change Orders
- Equipment Inspection
- Authorized Service Centers
- Servicing Guidelines

Section 2.0 Warnings and Cautions 17
- Cautions
- Warnings
- ESDS Warnings and Cautions

Section 3.0 Specifications and Alarms 21
- Front Panel Controls
- Alarms
- Front Panel Visual Indicators
- Physical Dimensions
- Power Sources
- Connections for 220 or 240 VAC Operation
- Battery Storage Specification
- Hardware Alarms
- Latched Alarms
- Silence Alarms
- No-Silence Alarms
- Alarm Silence Period
- Alarm Descriptions
- Alarm Matrix

Section 4.0 Troubleshooting Chart 35
- System Start-Up Problems
- Failure Alarms and LED Indications
- Piston Operation Problems
- Dump Valve Problems
- Oxygen Flow Problems
- Error Codes
- Miscellaneous Problems

Section 5.0 Operational Checks 47
Operational Checks
Using an RT-200A
Diagnostic Check
Unit Start-up and AC/DC Operation
Power Board Voltages
Chassis to Ground Test
Low Voltage Alarm Test
Leakage Current Check
Ground Resistance Test
Tidal Volume Display Range
Rate: Patient BPM Display Range
Inspiratory Flow Rate Display Range
I:E Ratio Display Range
Measure Volume Delivery
Outer Limit Switch Operation
Zero Reference Solenoid, Pressure Gauge Check
Cylinder Leakage Check
Dump Valve
Pressure Relief Valve Operation
Control Mode Operation
Control + Sigh Mode Operation
Assist Control Mode Operation
Assist Control + Sigh Mode Operation
SIMV Mode Operation
Low Pressure Alarm Time Out
Low Pressure Alarm Setting
Oxygen Delivery Check
Oxygen Source Pressure Alarm Test

Section 6.0 Preventive Service 63
Preventive Service Procedures
Mandatory Engineering Change Orders (ECOs)
Complete Motor Change Requirements
Quality Assurance Check-out Procedures

Section 7.0 Disassembly, Inspection, and Reassembly 67
Remove the Top, Bottom, and Side Panels
Lower the Left Module
Toroid Assembly Replacement
Lowering the Front and Right Module
Bulkhead Heatsink Removal
Power Board Removal
Logic Board Removal
Vent Assembly Removal (for units with power board 37901)
Airway Pressure Limit Calibration (for units with power board 37901 and a vent assembly)
Electronic Dump Service (for unit with power board 37988)
Calibrate Airway Pressure Limit (for units with an electronic dump and power board 37988)

Section 7.0 Disassembly, Inspection, and Reassembly (Continued)
Patient Outlet Removal
Back Module Removal
Encoder and Terminal Jack Assemblies
Motor Assembly Removal
Motor Lead Resistance Test (optional)
Silent Block/Ball Screw Assembly
Bulkhead, Cylinder, and Piston Service
Ball Screw Assembly Inspection
Ball Screw Assembly Lubrication
Alarm Replacement
Alarm Block Assembly Change Out
Oxygen Valve Inlet Fitting Filter Change
Reconfiguring the RAAS for the PLV-102
Changing the Connector
Final Unit Reassembly

Section 8.0 ECO Changes **97**
Mandatory Engineering Change Orders
ECO #: 2088 Installation of Capacitor Auxiliary Board
ECO #: 2692 Timer Circuit Resistor (R19) Change
ECO #: 2863 Power Board Motor Drive Circuit Improvement
ECO #: 2992 Krytox Lubrication Change
EPROM Release
ECO #: 3288 Reset Pulse Capacitor (C39) Change
ECO #: 4000 EPROM Version 7.3 and Internal Regulator Pressure Port Change
ECO #: 4705 Relocating the Inlet Valve Leaf
PLV-102 Backlight Installation
ECO #:6007 Backlight Inverter Change
ECO #:6026 Alarm Assembly Change Out

Section 9.0 Run-In **115**
Run-In Requirements
Guidelines

Section 10.0 Calibration and Testing **117**
PLV-102 Calibration
Internal Battery and Alarm Capacitor Test
Zero Reference Solenoid Valve
Diagnostic Check
Diagnostic Alarm
Internal Battery Operation
External Battery Operation
Low Voltage Alarm Test
Low External Battery Test
Power Failure Alarm Test
Power Board Voltages
Chassis to Ground Test
Cylinder Leakage Check
Resistance, Chassis to Oxygen Sensor Jack
Calibration Set-up

Section 10.0 Calibration and Testing (Continued)
Unit Calibration
Oxygen Source Test
Internal Regulator Creep Test
Oxygen Delivery Check
Oxygen Source Pressure Alarm Test
Limit Switch Operation Check
Pressure Relief Valve Operation
Pressure Gauge Check
Low Pressure Alarm Setting Check
Pressure Vent Low Limit
Pressure Vent High Limit
Assist Control Mode Operation
SIMV Mode Operation
Remote Alarm Circuit Check
Leakage Current Check
Ground Resistance Test
Service Requirements

Section 11.0 Theory of Operation **135**

Logic Board Introduction
Central Processing Unit
Memory Addressing
NOVRAM Memory
System Clocks
Resets and Watch-Dog Timer
Processor I/O Addressing System
Digital Output Ports
Analog to Digital Conversion
Data Input Signals
8254 Counter/Timer
Encoder Pulse Counting
Zero Position Detection
Analog System
Pressure Measurement
LCD Displays
Oxygen System
Front Panel Assembly
Back Panel Assembly
Remote Alarm Connector
Oxygen Valve
Data Input Signals (PLV-102 with Backlights 37992 Logic Board)
Encoder Pulse Counting (PLV-102 with Backlights 37992 Logic Board)
LCD Backlights (37992 Logic Board)

Theory of Operation Power Board 37901, Revisions A thru H **162**
Power Board Operation
DC Operation and System Switching
Internal Battery Charger
External Battery Charger

Theory of Operation Power Board 37901, Revisions A thru H (Continued)
13.8 Volt Regulator
+5 Volt Digital Regulator
+8 Volt Analog Regulator
Dump Valve Driver
Oxygen Valve Driver
Hardware Alarm Circuits
Alarm Driver Circuit
Relay and Solenoid Drivers
Motor Drive Bridge
Motor Drive Logic
Pressure System

Theory of Operation Power Board 37901 Revision I **171**
Power Board Operation
DC Operation and System Switching
Internal Battery Charger
External Battery Charger
13.8 Volt Regulator
+5 Volt Digital Regulator
+8 Volt Analog Regulator
Dump Valve Driver
+5 Volt Miscellaneous Regulator
Oxygen Valve Driver
+5 Volt Oxygen Regulator
Hardware Alarm Circuits
Alarm Driver Circuit
Relay and Solenoid Drivers
Motor Drive Bridge
Motor Drive Logic
Pressure System

Theory of Operation Power Boards 37988 and 37864 ..... **180**
Power Board Operation
DC Operation and System Switching
Internal Battery Charger
External Battery Charger
13.8 Volt Regulator
+5 Volt Digital Regulator
+8 Volt Analog Regulator
Dump Valve Driver
Oxygen Valve Driver
Hardware Alarm Circuits
Alarm Driver Circuit
Reverse External Battery Alarm
Low Voltage Alarm
Dump Alarm
Software Alarms
Relay and Solenoid Drivers
Motor Drive Bridge
Motor Drive Logic

Theory of Operation (Continued)
Pressure System
Zero Board
Cylinder Module
Limit Switches
Ball Screw Drive
Ballnut Follower
Motor Encoder

Section 12.0 Domestic Parts List **191**

Section 13.0 International Parts List **225**
International/220V Parts List
PLV-102 German Parts List
PLV-102 Swedish Parts List
PLV-102 Japanese Parts List
PLV-102 French Parts List
PLV-102 Dutch Parts List

Section 14.0 Schematics **251**
PLV-102 Wiring Diagram
120 Volt Wiring Diagram
220 Volt Wiring Diagram
Japanese Wiring Diagram
Swedish Wiring Diagram
Power Board #37901, Revision A through H
Power Board #37901, Revision I
Power Board #37988, New Style
Power Board, Military Version
Power Board, #37E864
Logic Board
Logic Board with Backlights
Serial Interface
O_2 Valve Control Board
Zero Board
Assy, Bulkhead Heatsink
Capacitor Aux. Board
Transformer, Toroid
Hour Meter, PLV-102

Introduction

Section 1.0

About this Manual
Servicing and Warranty
Service Location
Service and Inspection Forms
Recommended Service, Repair, and Test Equipment
Engineering Change Orders
Equipment Inspection
Authorized Service Centers
Servicing Guidelines

About this Manual

▼ This manual is intended for use when servicing the Respironics® PLV-102. Sections covering troubleshooting, circuit descriptions, and testing are included. Personnel servicing the PLV-102 must be thoroughly familiar with the PLV-102 Operating Manual and the ventilator's functions. The information contained within this document is subject to change without notice.

This procedure is written for a technician experienced in volt meter usage, soldering, and electrical troubleshooting. **Do not attempt to repair the PLV-102** otherwise. Unauthorized repair voids the warranty. Refer to the PLV-102 Operating Manual for complete warranty information.

A **WARNING** notifies when there is a possible hazard or danger to the Patient or Service Personnel.

A **Caution** notifies when possible damage may occur to the device.

Servicing and Warranty

▼ It is recommended that the PLV-102 be serviced by an authorized Respironics Customer Satisfaction Center once per year or every 8,000 hours recorded on the hour meter, whichever comes first. This allows Respironics Service Personnel to check the performance of the unit, check the electrical integrity, and replace parts as necessary.

Respironics warrants the PLV-102 to be free from defects in material and workmanship for a period of one year after delivery, provided that the unit is properly operated, under normal conditions. Respironics makes replacements, repairs, or issues credit for equipment or parts which are found to be defective. The defective unit may be returned prepaid to Respironics after the customer has received approval from Respironics to return the unit.

This warranty does not apply to any unit or individual parts which have been repaired or altered in a way that, in Respironics' judgement, affects the stability or reliability, or which has been subjected to misuse, negligence, abuse, or accident.

This warranty does not cover damage which may occur during shipping. If there is any damage during shipping, please contact the carrier or individual who delivered the unit.

Respironics offers a month-to-month maintenance contract on the PLV-102. The maintenance contract covers all parts, labor, and loaner ventilators. If a unit is out of warranty, and a maintenance contract is desired, it is necessary for the owner to submit the unit to Respironics or a Respironics distributor for servicing, on a time and material basis, to bring the unit in-line with Respironics standards. The unit may then be placed under a month-to-month maintenance contract.

Servicing and Warranty (Continued)

Respironics®, Inc., and Respironics® Colorado, Inc. have a policy of continued product improvement and reserve the right to alter specifications without notice.

Service Location

▼ The PLV-102 (37001) may be repaired at any Respironics Customer Satisfaction Center located throughout most of the world. Please call 800/669-9234 for the location of the Respironics Customer Satisfaction Center nearest you.

WARNING: Federal law restricts this device to sale by or on the order of a physician.

Service and Inspection Forms

▼ Use the following forms and procedures during servicing or inspection of the PLV-102:

37Q-001	PLV-102 QA Final Inspection Form
37I-001	QA Final Inspection for PLV-102
37500	PLV-102 Clinical Manual
37505	PLV-102 Service Manual

Current revisions of these forms and procedures may be obtained from any Respironics Customer Satisfaction Center or by contacting:

Respironics Colorado, Inc.
Attention: Technical Services
1401 W. 122nd Avenue
Westminster, CO 80234-3421 USA
TEL: 800/659-9235 FAX: 303/255-9000

Recommended Service, Repair, and Test Equipment

Respironics Part Number	Description
98555	Torque Driver
98557	Socket, ¼" Drive x 5/16"
98260	Tie Wrap Gun
90902	Gate Valve Assembly
90019	Sound Level Meter Tester Tool
90037	Pressure Restricter, PLV
90903	Test Gauge Assembly, O_2 Regulator
90904	Test Gauge Adapter Assy.
27324	Oxygen Conductive Hose
27019	Printer Cable Assembly (PLV-102)
98559	Allen Driver Set
98560	Nut Driver Set
98251	Soldering Station
98577	Fluke Meter/Ohmmeter (Multimeter)
98144	Solder Wick, 110" Copper
98128	Wrist Strap, Antistatic
98129	Wrist Cord, Antistatic
98906	Cord, Wrist Strap, Grounding
98537	Mat, Table, Antistatic, 2' x 4'
98265	Shunt, 1 Meg Ohm
98561	Pliers, Snap Ring
98565	Heat Gun
98576	Safety Inspector, SI-100 Tester
98607	Socket Adapter, ¼", Torque Driver
06121	PLV Hose Assembly
06335	Connector, Adapter 22 mm
06348	Coupler, 22 mm I.D.
06658	Test Lung, 1 liter
06712	PEEP Valve
	Timeter RT-200A
Miscellaneous Equipment:	0-12 Volt Adjustable DC Power Supply
	Wire Cutters
	Needle Nose Pliers
	Regular Pliers
	Straight Blade Screwdriver
	Jewelers Screwdriver Set
	Phillips Head Screwdriver
	Wire Strippers
	External Retaining Ring Tool
	Hemostat, 6" Soldering
	Solder, Pure, 60/40
	Jumper Wire with 1K ohm Resister
	* Calibrated Respironics® Pressure Alarm
98573	* Magnehelic Gauge, 0-20 cm H_2O
98574	* Magnehelic Gauge, 0-150 cm H_2O
	* Digital Pressure Manometer

* Can be used in place of the Timeter RT-200A

Engineering Change Orders

▼ Any ECO not installed in a unit, must be installed during service of the PLV-102 unless it is listed as optional in this service manual. ECOs are found in Section 8.0 of this manual.

Equipment Inspection

▼ It is standard operating procedure for Respironics Distributors and Customer Satisfaction Centers to perform a final QA Inspection of the PLV-102 after servicing a unit or upon receipt of a new unit.

It is mandatory that all Respironics service personnel follow the QA Final Inspection for the PLV-102 (37I-001) before the unit is released to a client. These inspection guidelines provide a step-by-step procedure for documenting the results of tests performed on the operation of a PLV-102.

Final QA inspection performed on a PLV-102 includes such criteria as internal and external inspection, diagnostic check, airway pressure, flow and rate check, and shipping configurations. The results, date and inspector's signature are recorded on each inspection form.

Any PLV-102 rejected during finished device inspection, and later reworked, must receive another complete QA Final Inspection.

Authorized Service Centers

▼ Respironics recognizes the need for outside centers to maintain their own equipment. To ensure quality service, Respironics has developed a Service Center Certification Program consisting of two parts; facility inspections and personnel training and certification.

The Service Center Certification is designed to ensure that a certified service representative has at their disposal the proper facilities necessary to complete quality repairs.

Only those facilities which are authorized Respironics Service Centers are sold replacement parts. For information on becoming an authorized service center contact Technical Services at 800/659-9235.

Servicing Guidelines

▼ Perform the decontamination procedure for returned equipment upon initial receipt of a ventilator from the client or hospital. The decontamination procedure must be completed before beginning service or handling the unit.

If the number of Hours Remaining since the last Preventive Service is GREATER than 6,500 hours, and the unit **is not** being serviced due to a complaint, perform Operational Checks (Section 5.0). If the unit fails Operational Checks, perform the steps in Sections 6.0 through 10.0.

NOTE: DO NOT change or replace the Preventive Service Due label behind the filter housing if a Preventive Service is not performed. The number of hours recorded on this label must be maintained for any future service required.

If the number of Hours Remaining is LESS than 6,500 hours, and the unit **is not** being serviced due to a complaint, perform Operational Checks. If the unit passes Operational Checks, perform Preventive Service (Section 6.0) and Calibration (Section 10.0).

NOTE: A unit passes Operational Checks if no discrepancy is discovered in unit operation other than, volume adjustment, dump valve adjustment, internal battery replacement, pressure relief valve adjustment, gauge replacement, power board voltage adjustments, or other minor repairs or adjustments that do not require disassembly of the unit other than the top and bottom panels.

If the unit **is** being serviced due to a complaint, perform Operational Checks in Section 5.0 to find any other discrepancies with unit operation. The steps in Sections 6.0 through 10.0, including Preventive Service MUST also be performed, regardless of the number of hours remaining.

If the unit is being serviced due to a complaint, the appropriate steps in Sections 5.0 through 10.0 must be performed to solve the problem, including preventive service.

A unit automatically fails operational checks if any mandatory ECO is not installed.

Refer to the flow chart on the next page for a further description of servicing guidelines.

Servicing Guidelines
(Continued)

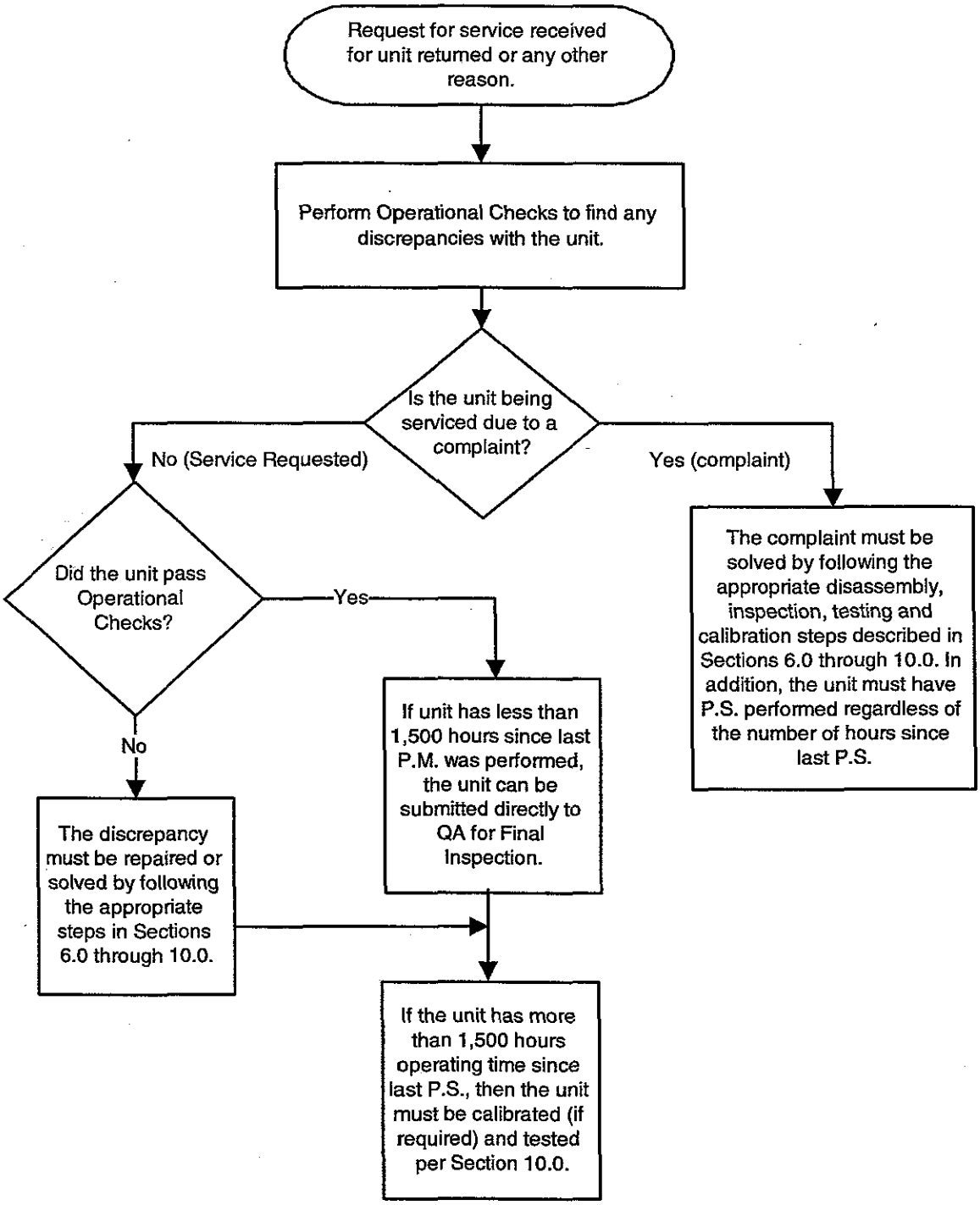

Request for service received for unit returned or any other reason.
Perform Operational Checks to find any discrepancies with the unit.
Is the unit being serviced due to a complaint?
No (Service Requested)
Yes (complaint)
Did the unit pass Operational Checks?
Yes
No
The complaint must be solved by following the appropriate disassembly, inspection, testing and calibration steps described in Sections 6.0 through 10.0. In addition, the unit must have P.S. performed regardless of the number of hours since last P.S.
If unit has less than 1,500 hours since last P.M. was performed, the unit can be submitted directly to QA for Final Inspection.
The discrepancy must be repaired or solved by following the appropriate steps in Sections 6.0 through 10.0.
If the unit has more than 1,500 hours operating time since last P.S., then the unit must be calibrated (if required) and tested per Section 10.0.

Figure 1: *Servicing Guidelines*

(This page intentionally left blank)

Warnings and Cautions

Section 2.0

Warnings
Cautions
ESDS Warnings and Cautions

Warnings

- The use of a water trap and/or hydrophobic filter is recommended to prevent moisture from entering the ventilator.
- The use of bacteria filters are recommended to ensure client safety from cross contamination.
- Verify the oxygen concentration, prior to and during patient use, using an oxygen analyzer that has been properly calibrated.
- DO NOT use the PLV-102 in the presence of flammable anesthetics.
- DO NOT operate the PLV-102 from the same battery that powers an electric wheelchair. Doing this may reduce the operating time of the PLV-102 from the 12 VDC external power source.
- There is always a possibility of unpredictable failure with any mechanical or electronic device. Should a patient's condition be such that his/her safety and health may be threatened by equipment failure, it is the USER'S RESPONSIBILITY to assure that a trained attendant is present at all times and that alternate respiratory equipment is available as required.

Cautions

- The PLV-102 must be periodically checked and maintained to ensure proper operation.
- Connect the PLV-102 to a grounded hospital grade outlet only.
- PLV-102 performance is affected at temperatures below -5°C (23°F) and above 41°C (106°F).
- DO NOT use the PLV-102 to charge a deeply discharged external battery. An external, 10-amp battery charger is recommended.
- Connect the external 12 VDC battery cable as follows:

  a. WHITE wire to POSITIVE (+) battery terminal.
  b. BLACK wire to NEGATIVE (-) battery terminal.

- PLV-102 performance may be affected when the internal batteries reach a "low voltage" alarm condition.
- DO NOT disconnect an external battery while the unit is operating under load. This may cause the unit to repeat the diagnostic start-up cycle.
- Oxygen may be added using a 50-psig high pressure oxygen hose. DO NOT use oil or grease in or near oxygen equipment or near the PLV-102 ventilator.

Cautions
(Continued)

- Replace the back panel shipping fuse, as required, with a 5-amp slow blow fuse, type 3AG.
- Positioning the PLV-102 must not block the air intake ports located on the rear panel.
- The PLV-102 power transformer is rated between 105 and 130 VAC, 60 Hz, sine wave input. Due to the wide variety of wave forms and voltage produced by inverters, it is recommended that the PLV-102 only be operated on a 12 VDC power supply when used in mobile vehicles such as ambulances and aircraft.
- Verify that the alarms are set correctly and are operational.
- It is recommended that the oxygen sensor is plugged-in and unplugged only when the unit is turned off.
- When oxygen is used, the ventilator's performance may vary at source pressures other than 50-psig and at peak flows below 20 LPM.
- Disconnect the 50-psig oxygen source when the PLV-102 is not in use.
- Oxygen accuracy refers to an oxygen percent, not a percent of the set oxygen.
- The internal batteries are a transitional power source to power the ventilator when switching between AC and external battery power. Do not use the internal batteries for more than 15 minutes.
- When not in use, plug the PLV-102 into AC power. This maintains the internal batteries in the best condition possible.
- Battery operation time 12 VDC internal battery: designed to meet ASTM standards of at least 15 minutes, when properly maintained.
- The internal batteries can be damaged if the PLV-102 is stored for long periods of time without recharge. For proper internal battery maintenance, the unit must be connected to an appropriate VAC power source for 24 hours at least every three weeks.
- Storage of the unit with a partially discharged internal battery severely decreases battery life. Always store the unit with the power plug connected to AC voltage or only after fully charging the internal battery from AC voltage.
- Frequent and/or prolonged use of the unit on internal batteries shortens the battery life. This requires close monitoring of the battery strength and may require battery replacement sooner than the normal maintenance interval.

ESDS Warnings and Cautions

- All ESDS items must be stored in approved conductive packaging, tubes, shipping bags, foam, or tote bins.
- All persons handling ESDS items must be grounded via a 1 Meg ohm resistive grounded wrist strap.
- Cover all ESDS bench tops with grounded conductive mats and connect all work surfaces and equipment to earth ground.
- Transport all assemblies containing ESDS items in a conductive bag or container.
- DO NOT use cellophane adhesive tape to wrap DIP (dual in-line package) tubes together.
- DO NOT handle ESDS items by their pins or mix them with other routine electronic parts.
- Never place ESDS items on ungrounded surfaces or leave them unattended in an open area.
- Avoid cellophane wrappers, synthetic carpeting, warm or cool air blasts, styrofoam coffee cups, etc. when working with ESDS items.
- Use only ESD safe solder suckers, grounded soldering irons, and grounded DIP installation tools.
- Use only properly designed heat lamps, heat chambers, and/or "antistatic" quick-chill sprays during troubleshooting or stress testing procedures.
- The following assemblies in the PLV-102 are easily damaged by ESD and require special handling:

  Logic Board (Front Panel Assembly)
  Zero Board (Bulkhead Assembly)
  Power Board (Right Module)
  O_2 Valve Control Board (Older Style Units)
  Encoder Assembly (Mounted to Motor)

Specification and Alarms

Section 3.0

Front Panel Controls
Alarms
Front Panel Visual Indicators
Physical Dimensions
Power Sources
Connections for 220 or 240 VAC Operation
Battery Storage Specification
Hardware Alarms
Latched Alarms
No-Silence Alarms
Alarm Silence Period
Alarm Descriptions
Alarm Matrix

Front Panel Controls

- **Mode Selection**
  CONTROL, CONTROL+SIGH, ASSIST/CONTROL, ASSIST/CONTROL+SIGH, SIMV
- **Tidal Volume**
  0.05 to 0.20 liters ± 0.02 liters; 0.20 to 3.00 liters* ± 10%
- **Sigh Volume (if applicable)**
  150% of Set Tidal Volume (The maximum possible sigh volume is 2.8 liters).
- **Sigh Frequency (if applicable)**
  1 Sigh Breath every 100 Tidal Breaths
- **Breath Rate**
  2 to 35 BPM ± 0.5 BPM; 36 to 40 BPM ± 2 BPM
- **Inspiratory Flow Rate****
  10 to 120 liters per minute ±10%
- **Battery Test Switch**
  Internal, External Battery
- **Main Power Switch**
  On, Off
- **5 Amp Circuit Breaker**
  Push-Pull Actuation
- **2 Amp Circuit Breaker**
  Push-Pull Actuation
- **Airway Pressure Limit**
  5 to 100 cm H_2O ± 5 cm H_2O
- **Sensitivity**
  +18 cm H_2O ± 1 cm H_2O to at least -5 cm H_2O
- **Low Pressure Alarm**
  2 to 40 cm H_2O ± 2 cm H_2O; 41 to 50 cm H_2O ± 5 cm H_2O
- **Manual Sigh**
  Push to activate one breath
- **Oxygen Percent**
  21% to 90% ± 6%
- **Oxygen Sensor (SIMV Operation)**
- **30-second Alarm Silence Button**
  Push to Activate

* A piston limit switch engages at or above 2.80 liters.

** Peak Flow rate during inspiratory time.

Alarms

- **Low Pressure**
  Visual/Continuous Audible
- **High Pressure**
  Intermittent Audible
- **Apnea**
  Visual/Continuous Audible
- **Inverse I:E Ratio**
  Visual Warning
- **Increase Inspiratory Flow**
  Visual Warning
- **Low Internal Battery**
  Visual/Continuous Audible
- **Low External Battery**
  Visual/Continuous Audible
- **Reverse Battery Connection**
  Continuous Audible
- **Power Failure**
  Continuous Audible
- **Unit Malfunction**
  Intermittent Audible
- **Power Source Change**
  Audible
- **Oxygen**
  Continuous Audible

Front Panel Visual Indicators

- **Manual Sigh**
  Yellow Indicator Light
- **Tidal Volume**
  Digital Display
- **Rate: Patient Breaths Per Minute**
  Digital Display
- **I:E Ratio**
  Digital Display
- **Inspiratory Flow Rate**
  Digital Display
- **Increase Inspiratory Flow**
  Red Indicator Light
- **120 (220/240) VAC Power**
  Green Indicator Light
- **Internal Battery Source**
  Amber Indicator Light
- **External Battery Source**
  Yellow Indicator Light
- **Patient Airway Pressure***
  -10 to +100 cm H_2O ± 5 cm H_2O
- **Assist/Spontaneous**
  Green Indicator Light
- **15 Second Delay (Low Pressure Alarm)**
  Green Indicator Light
- **Oxygen Percent**
  50% and Greater Marked Red
- **30 Second Alarm Silence**
  Yellow Indicator Light/Push-button
- **Alarm Code Display (in flow window)**
  Digital Display

* Pressure wave form sinusoidal drive on all breaths.

Physical Dimensions

- **Overall Dimensions**
  9" high x 12.25" wide x 12.25" deep
  (22.9 cm x 31.1 cm x 31.1 cm)

- **Weight**
  28.9 lb (13.1 Kg)

Power Sources

- **12 VDC External Battery**
- **12 VDC Internal Battery**
- **120 VAC 50/60 Hz***
- **220/240 VAC 50/60 Hz (International Models)**

*NOTE: Throughout the entire Service Manual, "120 VAC 50/60 Hz" shall also imply "220/240 VAC 50/60 Hz" on International Models.

Model	Country	Power Sources
37001	Domestic	120 VAC 50/60 Hz, 12 VDC
37002	International	220/240 VAC 50/60 Hz, 12 VDC
37003	German	220/240 VAC 50/60 Hz, 12 VDC
37004	Swedish	220/240 VAC 50/60 Hz, 12 VDC
37006	Japanese	100 VAC 50/60 Hz, 12 VDC
37007	French	220/240 VAC 50/60 Hz, 12 VDC

Connection for 220 or 240 VAC Operation

▼ International model versions of the PLV-102 may be wired to accept 220 or 240 VAC input current. Both operate between 50 and 60 Hz, (see figure 2).

- **220 VAC Operation:**

  Connect the brown lead from the toroid transformer to the white AC lead from the RFI assembly on the back panel module. The two black wires are connected as shown in figure 2.

- **240 VAC Operation:**

  Connect the white lead from the toroid assembly to the white AC lead from the RFI assembly on the back panel module. The two black wires are connected as shown in figure 2.

Connections for 220 or 240 VAC Operation
(Continued)

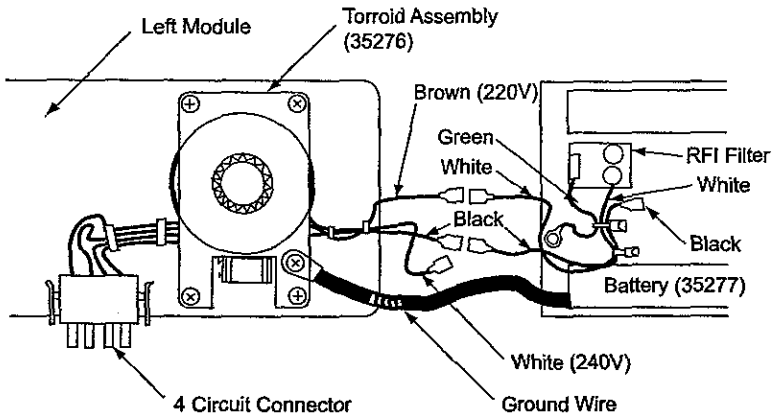


Figure 2: *Connections for 220/240 VAC*

Battery Storage Specifications

▼ Fully charged batteries last as long as three years when stored at room temperature (70° F). This means that after three years the battery is at 80% capacity. (Note: 80% is the definition of when a lead acid battery is no longer useful). Any deviation from 70° F has the following result: For every 10° F increase in temperature the storage life decreases by 50%, conversely for every 10° F decrease in temperature the storage life increases by 100%.

Self discharge is the normal process by which a battery loses a stored charge in an open circuit operation, such as storage. The chemical process that occurs is called sulfation, where the lead on the internal grids of the battery sulfates. This produces crystals that function as insulators that inhibit the operation and charging process of the battery. If this sulfation has occurred to the point that the battery capacity has been depleted to less than an 80% level, then normal charging circuits no longer are able to charge these batteries, and the batteries must be replaced.

To achieve the maximum storage life, store batteries fully charged. Physical orientation of the battery (as in upright, laying down, etc.) is unimportant and does not effect the stored battery life.

Check that all batteries are fully charged before storing units. To fully charge batteries, run the units on AC power, as per the Run-In Section. If the battery has been discharged to 80% capacity level, a four hour charge is required to bring the battery to a minimum of 90% charge. An additional twelve hours is required to fully charge the battery.

Inform users of the ventilators that this unit is designed to provide power when switching from AC power to DC power, or in an emergency.

Hardware Alarms

▼ An alarm is a condition that is reported by four routes.

1. Audible signal between 70 and 80 decibels and a frequency of 2.9 KHz ±0.5 for at least 1.5 seconds. The audible signal pattern and duration is defined for each particular alarm. The audible signal continues until the alarm is cleared as defined in the alarm matrix or until at least 1.5 seconds have passed.

2. Flashing alarm code in the peak flow LCD. The alarm code remains flashing in the peak flow LCD until the alarm is cleared by the alarm silence button (if possible for that alarm) or until the unit is turned off or until 30 seconds after the alarm clears itself as defined in the alarm matrix.

3. Alarm code and message sent to the serial interface for a computer terminal or printer. The alarm code and message sent to the serial interface is only sent once for each alarm occurrence at the time the alarm is first reported.

4. Alarm signal sent to the BNC connector for remote alarm systems. The signal to the remote BNC connector begins when an alarm is reported and continues until the alarm is cleared as defined or until 1.5 seconds have passed, whichever is longer.

Latched Alarm

▼ A latched alarm is an alarm that is not controlled by the software or affected by the alarm silence function. Hardware alarms are reported by two routes:

1. Audible signal which may be a 'solid' signal or a 'chirping' signal

2. A flashing LED assigned to a hardware alarm.

Silence Alarms

▼ An alarm that is reported at the end of an alarm silence period when it has occurred during the alarm silence period, even if that alarm condition has cleared. If a latched alarm occurs during an alarm silence period, it immediately sends the alarm message to the printer/terminal interface. At the end of the alarm silence period, it sounds the audible signal, flashes the alarm code in the peak flow LCD, and sends the alarm signal to the remote BNC connector. If there is more than one latched alarm at one time, only the alarm with the highest priority is displayed flashing in the peak flow LCD, at the end of the alarm silence period, but each alarm code and message is sent to the terminal as they occur.

No-Silence Alarms

▼ An alarm that is not affected by the alarm silence function. If a No-Silence alarm occurs during an alarm silence period, it is immediately reported as if there was no alarm silence period. If the alarm silence button is pushed during a No-Silence alarm, it has no effect. For any type alarm condition, however, the remote alarm signal to the BNC connector is in a 'no alarm' state during any alarm silence period.

Alarm Silence Period

▼ A period of 30 seconds initiated by pushing the Alarm Silence Button during which no alarm is reported (except No-Silence alarms). The alarm message is still sent to the printer/terminal interface, however, as the alarm occurs.

Each time the alarm silence button is pushed and released it extends the alarm silence period for 30 seconds from the time that the button is pushed. If the alarm silence button is pushed during an alarm (except a No-Silence alarm), it silences the audible alarm and cause the peak flow reading to return in the peak flow LCD. An existing alarm that is silenced is not reported again unless it occurs again. If the alarm silence button is pushed before an alarm condition exists, no alarm is reported (except a No-Silence alarm) for 30 seconds.

Alarms that occur and whose condition clears during this 30-second period (except for Latched alarms and No-Silence alarms), are not reported. If the alarm condition still exits at the end of the 30-second period, it is then reported. If the alarm silence button is held down, it causes the last alarm code to flash in the peak flow LCD until the alarm silence button is released. Also, each time the alarm silence button is pushed it causes the regular print message to be sent to the printer/terminal interface.

Alarm Descriptions

▼ The fault number and message of each alarm are reported only through the connector to the printer or terminal. The alarms are listed in ascending priority.

Note: The newer style PLV-102's with backlights also provide extended Alarm Code information. The extended Alarm Code first flashes the main alarm number, such as "A1", and then flashes the decimal number of the specific alarm condition, such as -3. This indicates that the Alarm Code is A 1.3 - "AC line voltage low." The extended alarm code is provided to help troubleshoot an alarm condition.

Alarm Descriptions
(Continued)

The following conditions cause an "A1" to flash in the Peak Flow LCD.

Alarm Code 1.3 - AC line voltage low
This alarm occurs when the AC line voltage has dropped so that the toroid output is below 6 volts DC. This is a latched alarm.

Alarm Code 1.4 - External battery capacity low
This alarm occurs when the external battery is in use and its voltage is below 9.5 volts. There is a 'hardware' alarm that occurs in conjunction with this alarm that 'chirps' during the piston stroke as the voltage approaches 9.5 volts and flashes the external battery LED. The external battery LED continues to flash until the external battery is disconnected or it regains voltage above the internal battery. When it drops below 9.5 volts the Fault 1.4 alarm is reported. Two minutes after switching to the internal battery the unit starts monitoring the external battery voltage and switches back to the external battery when it exceeds the voltage of the internal battery.

Alarm Code 1.5 - Internal battery low
This alarm occurs when the internal battery is in use and its voltage is less than 9.5 volts. There is a 'hardware' alarm that occurs in conjunction with this alarm that 'chirps' during the piston stroke as the voltage approaches 9.5 volts and flashes the internal battery LED. The internal battery LED continues to flash until another power source is attached. When it drops below 9.5 volts, the Fault 1.5 alarm is reported.

Alarm Code 1.6 - Switching to internal battery
This alarm occurs when the unit is switching its power source to the internal battery. It occurs directly after either Fault 1.3 or 1.4. This alarm is a latched alarm.

Alarm Code 1.7 - Switching to external battery
This alarm occurs when the unit is switching its power source to the external battery. It occurs either directly after Fault 1.3 or when the unit switches from the internal battery to the external battery. This alarm is a latched alarm.

The following conditions cause an "A2" to flash in the Peak Flow LCD.

Alarm Code 2.1 - Momentary low pressure alarm
This alarm occurs when the patient airway pressure is below the low pressure set point for at least 15 seconds. This alarm does not occur in the SIMV mode.

Alarm Code 2.2 - Low pressure alarm persistent 2-3 breaths
This alarm occurs when the low pressure alarm condition (2.1) has been seen in at least two out of the last three breaths. This alarm does not occur in the SIMV mode.

Alarm Code 2.3 - SIMV patient disconnect alarm
This alarm occurs in SIMV mode when the low pressure set point is not exceeded during a machine breath.

Alarm Descriptions
(Continued)

Alarm Code 2.4 - Apnea alarm (Momentary)
This alarm occurs in SIMV mode when a 15 second period goes by without either a sensed spontaneous effort or the pressure exceeding the low pressure set point.

Alarm Code 2.5 - Apnea alarm (Persistent)
This alarm occurs in SIMV mode when the apnea alarm (momentary) condition (2.4) has been seen in at least two out of the last three machine breath periods.

The following conditions cause an "A3" to flash in the Peak Flow LCD.

Alarm Code 3.1 - Momentary high pressure alarm
This alarm occurs when the dump valve has been opened to vent a high pressure situation. Two situations may trigger this:

1) The pressure has exceeded the airway pressure limit which has been set using the front panel knob.

2) While in a Sigh mode the pressure has exceeded the calculated pressure limit during a non-sigh breath. The audible portion of this alarm is a hardware alarm. The entire alarm is a No-Silence alarm.

The signal to the BNC connector for the Remote Alarm was lengthened to ensure that the Remote Alarm sounds for an adequate length of time.

Alarm Code 3.3 - Extreme overpressure at 105 cm water
This alarm occurs when the proximal airway pressure has exceeded 105 cm H_2O. This is a No Silence alarm.

The following conditions causes an "A4" to flash in the Peak Flow LCD.

Alarm Code 4.1 - Low oxygen flow on inspiration
This alarm occurs when the oxygen flow, measured by the thermistor, is lower than the particular percent oxygen as set on the front panel when a breath is delivered. During this alarm condition an oxygen source pressure test is performed on the next backstroke. If the source pressure test determines that the source pressure is 35 psi or above, then the alarm is cleared. If the source pressure test determines that the source pressure is less than 35 psi, then a fault 4.9 occurs.

Alarm Code 4.4 - Check oxygen sensor
This alarm occurs only during start-up in the SIMV mode. It is triggered if the Oxygen sensor reading of the room air is outside the normal range of 3 to 17 mV. This is a "No Silence Alarm".

Alarm Descriptions
(Continued)

Alarm Code 4.6 - High baseline O_2 flow reading
This alarm occurs after each backstroke when the thermistor reading is above 160, (refer to Step 3 of the Calibration Procedure in Section 10.0). This warns of either a faulty thermistor circuit or detection of oxygen flow when the unit is set not to deliver any additional oxygen. This is detected just before each forward stroke of the piston, or if in SIMV, right before the first spontaneous breath of each machine cycle. This alarm is cleared when the thermistor reading drops below 160 or by the alarm silence function.

Alarm Code 4.8 - Oxygen delivery out of range
This alarm occurs only in the SIMV mode when oxygen is called for and the oxygen sensor is in use. This alarm warns when the sensed oxygen differs by more than 10% from the front panel setting over ten consecutive breaths. A forty breath delay is started when the oxygen setting is changed during the ten breath monitoring period.

The following conditions cause an "AP" to flash in the Peak Flow LCD.

Alarm Code AP.1 - Parameter settings beyond O_2 delivery capability
This alarm occurs when the front panel settings results in a maximum oxygen flow which is greater than the maximum flow capable (80 lpm) through the proportioning valve at 50 psi.

Alarm Code AP.2 - High volume
This alarm occurs when the volume is set greater than 2.79 liters and the piston contacts the outer limit switch.

The following conditions cause an "A5" to flash in the Peak Flow LCD.

Alarm Code 5.1 - Pressure transducer fault
This alarm occurs when the PX10 ambient pressure reading is out of range for two readings in a row. This reading is taken at the beginning of each backstroke, and at least 10 seconds between readings.

Alarm Code 5.2 - Piston stalled
This alarm occurs if more than five seconds have elapsed since a machine breath cycle was expected to be complete. The breath cycle begins at the beginning of the piston backstroke. This is a "No Silence" Alarm.

Alarm Code 5.3 - Piston over-travel
This alarm condition occurs if the piston connects the inner limit switch at any setting, or if it connects the outer limit switch while the volume set on the front panel is less than 2.80 liters. This is a "No Silence" Alarm.

Alarm Code 5.5 - Piston stalled when pulsing
This alarm occurs when motor pulsing is not successful in moving the piston after it has stalled. This alarm occurs if five pulses have been sent to the motor successively without observing any movement. This is a "No Silence" alarm.

Alarm Descriptions
(Continued)

Alarm Code 5.7 - Internal battery circuit failure
This alarm occurs when a bad reading has been received from the battery capacity switch. This is a "No Silence" alarm.

Alarm Code 5.8 - Piston tracking system failure
This alarm occurs whenever the inner and outer limit switches are activated simultaneously. This is a "No Silence" alarm.

Alarm Code 5.9x - Internal system error
This is a "No Silence Alarm and has a three digit alarm code. This alarm occurs during one of the following conditions:

5.93 This alarm occurs when a number to be converted to BCD format by the PLV-102 software is too large.

5.94 This alarm occurs when a number being used to program the sector interrupt is out of range.

5.95 This alarm occurs when a number being converted to ASCII is out of range.

5.96 This alarm occurs when the number of characters of a number being inserted into a message is out of range.

5.97 This alarm occurs when the serial communications mode of operation has an illegal value.

5.98 This alarm occurs when the audible alarm type has an illegal value in the procedure that controls the audible alarm.

Alarm Code AP1 - Parameter settings beyond O_2 delivery capability
This is an alarm that occurs when the front panel settings would result in a maximum oxygen flow which is greater than the maximum flow capable through the proportioning valve. This is a "No Silence" alarm.

Alarm Code AP2 - High volume
This is an alarm that occurs when the volume is set greater than 2.70 liters and the piston contacts the outer limit switch. This is a "No Silence" alarm.

Alarm Code 1.0 displayed in the Tidal Volume Window at Start-up:
This indicates a failure of the Pressure Transducer, the zero reference solenoid, or their associated circuits.

Alarm Code 2.0 displayed in the Tidal Volume Window at Start-up:
This indicates a failure of the EPROM Checksum.

Alarm Code 2.1 displayed in the Tidal Volume Window at Start-up:
This indicates a failure of the NOVRAM IC on the logic board.

Alarm Matrix

Alarm Code	Latched	No-Silence	Hardware	Audible Portion	Cleared by
1.3	yes	no		constant	1
1.4	no	no	yes-chirp	constant	Switch to alternate power source
1.5	no	no	yes-chirp	constant	Switch to alternate power source
1.6	yes	no		constant	1
1.7	yes	no		constant	1
2.1	no	no		constant	1 or 2
2.2	no	no		constant	1 or 2 for two consecutive breaths
2.3	no	no		constant	1 or 2
2.4	no	no		constant	1 or 2
2.5	no	no		constant	1 or 2 for two consecutive machine breaths
3.1	no	yes	yes	constant for 1.5 seconds	1.5 seconds have passed
3.3	no	yes	yes	constant for 1.5 seconds	1.5 seconds have passed
4.1	no	no		constant	1 or source pressure rises above 35 psi
4.3	yes	no		constant	1 or just before 3 min. source press check
4.4	no	yes		constant	3 or sensor is detached from unit
4.6	no	no		constant	1 or thermistor reading drops below threshold
4.8	no	no		constant	1 or oxygen reading returns to within range
4.9	yes	no		constant	1 or pressure returns above 35 psi
AP.1	no	yes		constant	parameters returned to possible range
AP.2	no	yes		constant	volume turned down below 2.8 L
5.1	no	yes		Fast Beep	3
5.2	no	yes		Fast Beep	3 or condition clears
5.3	no	yes		Fast Beep	3 or next piston stroke does not hit limit switch
5.5	no	*yes		Fast Beep	*alarm silence clears and starts pulsing or 3
5.7	no	yes		Fast Beep	3
5.8	no	yes		Fast Beep	3
5.9x	no	yes		Fast Beep	3

1= Alarm Silence 2=Condition Clears 3=Unit Turned Off

(This page intentionally left blank)

Troubleshooting Chart

Section 4.0

System Start-Up Problems
Failure Alarms and LED Indications
Piston Operation Problems
Dump Valve Problems
Oxygen Flow Problems
Error Codes
Miscellaneous Problems

Troubleshooting Chart

NOTE: The possible causes and actions/solutions listed below are used as guidelines for troubleshooting the PLV-102. This list is **NOT** complete and other possible causes and solutions should **NOT** be ruled out. Refer to the Theory of Operation and PCB schematics, as required, to further troubleshoot the PLV-102.

If there is a problem with a certain part of a circuit, check the continuity of all traces, and inspect for fractured solder joints.

Problem	Possible Cause	Action/Solution
System Start-up Problems		
1.0 No AC or DC operation.	1.1 Defective power switch.	1.1 Check voltage across closed power switch. Replace power switch if voltage is measured.
	1.2 Broken wires at power switch.	1.2 Inspect wires at power switch. Replace wires if broken.
	1.3 Solder joint at switch terminal.	1.3 Inspect solder joints at power switch. Resolder connections if presence of poor wetting exists.
	1.4 Defective DC circuit breaker.	1.4 Check voltage across closed DC circuit breaker. Replace DC circuit breaker if a voltage of ~14 VDC is measured.
	1.5 No voltage at TP7.	1.5 Check Q5 (power board 37988), or Q9 (power board 37901). Replace as necessary.
	1.6 No voltage at TP1 or TP3.	1.6 Inspect Toroid assembly. Check RFI. Probe black and white wires on RFI assembly with meter on AC. Inspect P2 for loose or bad connections.
	1.7 No voltage at TP8.	1.7 Check Q20 on heat sink.
	1.8 No continuity or poor in-line connections.	1.8 Check connections at path of incoming raw power. Repair if connection is poor.
2.0 No AC operation, but unit operates on DC.	2.1 Damaged line cord.	2.1 Inspect line cord for damage. Replace cord if damaged.
	2.2 Defective AC circuit breaker.	2.2 Check voltage across closed AC circuit breaker. Replace AC circuit breaker if raw voltage is measured.

Problem	Possible Cause	Action/Solution
2.0 Continued.	2.3 No power at wall outlet.	2.3 Plug unit into a different outlet.
	2.4 Q17 is defective, (power board/ heat sink).	2.4 Probe P8 Pin 1, 4, 5. Replace as necessary.
	2.5 Toroid is defective.	2.5 Check Toroid output for a measurement of 17.8 VAC across RV2. Inspect toroid assembly. Check RFI by probing black and white wires on RFI assembly with meter set to AC.
	2.6 Microfuse on power board is blown.	2.6 Inspect fuse. Replace if blown.
3.0 No DC operation, but unit operates on AC.	3.1 Back panel fuse is open.	3.1 Inspect back panel fuse. Replace fuse if blown. Check for possible shorts in unit if fuse continues to blow.
	3.2 Internal battery not charged, or does not hold a charge.	3.2 Perform battery charging test for 24 hours. After charging battery, a voltage of 14.2 is present at TP1 or TP4. Discard battery if voltage is not present.
	3.3 External battery not charged, or does not hold a charge.	3.3 Replace external battery.
	3.4 DC power cord is defective.	3.4 Replace DC power cord.
	3.5 K600 (power board 37901) has failed, or K2 (power board 37988).	3.5 Probe for voltage at Q10, pin 3 (37988) or Q11 (37901). Replace K600 or K2 if no voltage is present.
4.0 Unit switches from AC to DC intermittently.	4.1 Defective power cord.	4.1 Measure voltage across power cord. Replace power cord if voltage fluctuates.
	4.2 Circuit breaker may or may not trip.	4.2 Reset breaker.
	4.3 Toroid or RFI is disconnected or has a bad connection.	4.3 Perform continuity checks on toroid or RFI circuit. Replace or repair as necessary.

Troubleshooting Chart

Problem	Possible Cause	Action/Solution
5.0 Unit intermittently operates when turned on.	5.1 Q501 is defective, (power board 37901).	5.1 Replace Q5.
6.0 Unit repeats self diagnostic test and does not start delivering breaths.	6.1 U19 on the logic board failed.	6.1 Check outputs at pins 17 and 18 of the 8254 timer. Output at pin 17 is high when a signal is present at pin 18.
	6.2 Open trace at U24.	6.2 Repair open trace.
	6.3 Pins 1 through 7 of U19 remain low when CLK 2 is high.	6.3 Replace U19.
	6.4 Output wave form out of specs between 10 and 10.5 MHz.	6.4 Replace oscillator.
7.0 LEDs flash and unit does not start-up.	7.1 Programmable logic array (U8) failed.	7.1 Replace U8 the LM1489 on the logic board.
8.0 Unit does not start-up when turned on and sounds a constant alarm.	8.1 Diode D8 on logic board failed.	8.1 Test D8 with a multimeter in the resistance mode. If the diode generates a low resistance reading when the multimeter leads are connected in both the forward and reverse biased positions then the diode is shorted and requires replacement.
	8.2 19R4 PAL is short, (logic board 37902).	8.2 Replace U13.
9.0 Unit sounds microprocessor alarm and does not begin diagnostic start-up.	9.1 U18 on logic board failed.	9.1 Replace U18.
10.0 Intermittent audible alarm during diagnostic start-up.	10.1 EPROM installed incorrectly or contains incorrect checksum.	10.1 Check for 2.0 indication in the volume display window.
	10.2 NOVRAM installed incorrectly or contains incorrect checksum.	10.2 Check for 2.1 indication in the volume display window.
11.0 Unit powers up but does not go through the diagnostic check.	11.1 U15 on logic board is defective.	11.1 Replace U15.
	11.2 U15 and U22 are shorted.	11.2 Replace U15 and U22.
12.0 All LCD displays stay lit when the unit is turned on.	12.1 Open trace at U9 and U13 is shorted.	12.1 Repair open trace and replace U13.

Problem	Possible Cause	Action/Solution
13.0 No operation and unit has a rapid alarm.	13.1 U18 is defective.	13.1 Replace U18.
Failure Alarms and LED Indications		
14.0 Alarm condition and all LEDs stay lit.	14.1 U15 is shorted.	14.1 Replace U15.
15.0 Unit alarms continuously.	15.1 U27 is shorted, (logic board 37902).	15.1 Replace U27.
	15.2 D8 is shorted open.	15.2 Replace D8.
	15.3 Internal/external tubing leaks.	15.3 Replace tubing
	15.4 Power switch SW1B shorted.	15.4 Replace power switch.
16.0 Unit constantly alarms and does not go through diagnostic check.	16.1 Open trace at U9.	16.1 Repair open trace.
17.0 Unit constantly alarms and all LEDs stay lit and all 8's appear in LCD windows.	17.1 U18 is shorted.	17.1 Replace U18.
18.0 Unit alarms continuously and blows 5 amp circuit breaker.	18.1 Q20 on bulkhead heat sink is shorted.	18.1 Replace Q20.
19.0 Unit stops and constantly alarms.	19.1 Q20 on bulkhead heat sink is shorted.	19.1 Replace Q20.
20.0 Unit constantly alarms in the on or off position.	20.1 Wire shorted to another wire on bulkhead heat sink.	20.1 Resolder shorted connection.
21.0 Constant alarm when unit is turned on.	21.1 50-pin connector shorted and has an open trace at P1.	21.1 Replace P1 and repair open trace.
22.0 Constant alarm that is barely heard then increases in volume with every piston stroke.	22.1 Q12 is shorted.	22.1 Replace Q12.
23.0 Unit does not sound an audible alarm.	23.1 Bad trace from the emitter of Q1 to R1.	23.1 Repair trace.
	23.2 Buss wire is disconnected at R4 and D3.	23.2 Resolder connection.
	23.3 D4 is shorted open.	23.3 Replace D4.

Troubleshooting Chart

Problem	Possible Cause	Action/Solution
23.0 Continued.	23.4 Power switch is open.	23.4 Replace power switch.
	23.5 Bad connection of faulty alarm transducer.	23.5 Resolder connection or replace alarm transducer.
24.0 When the unit switches to the internal battery, the amber LED flashes and 0 volts is displayed in the flow LCD when the Read Battery Volts switch is pressed.	24.1 ADC on logic board is defective.	24.1 Replace U3 (ADC).
25.0 Unit internal LED blinks when operating on fully charged batteries.	25.1 D603 is shorted open.	25.1 Replace D603.
26.0 Unit does not reset low pressure LED when pressure reaches LED turn off point.	26.1 Transducer inoperative.	26.1 Replace transducer.
Piston Operation Problems		
27.0 Piston stalls and sounds an A5 alarm, then operates normally.	27.1 U19 is defective (logic board 37902).	27.1 Replace U19.
28.0 Piston speeds up and contacts the limit switch	28.1 U8 on logic board defective.	28.1 Replace U8, the LM1489 on the logic board.
29.0 Piston movement after the completion of a breath.	29.1 Damaged traces at U24 which supply the chip's enable and NOVRAM clock signal.	29.1 Repair damaged traces.
30.0 Piston stalls.	30.1 U26 is not functioning properly when the unit has been running for a couple of hours.	30.1 Replace U26.
	30.2 Mechanical problem with the ball screw.	30.2 Replace as necessary.
	30.3 Tightness in the piston/cylinder.	30.3 Adjust as necessary. Replace as required.
	30.4 Zero board is defective.	30.4 Troubleshoot as necessary.
31.0 Piston is sticking.	31.1 Foreign substance on cylinder walls or on piston teflon surface.	31.1 Clean cylinder and piston.
32.0 Piston/cylinder clearance is too tight.	32.1 Cylinder ID is out of round.	32.1 Replace piston/cylinder.

Problem	Possible Cause	Action/Solution
32.0 Continued	32.2 Piston OD is out of round.	32.2 Replace piston/cylinder.
33.0 Piston over-drive to bulkhead or left end panel.	33.1 Limit switch open.	33.1 Check limit switches for proper operation.
	33.2 Push button switch open.	33.2 Cold solder joints at connections. Resolder or replace switch.
	33.3 Encoder failed.	33.3 Replace encoder.
	33.4 Zero board failed.	33.4 Replace D1 or Q1.
34.0 Piston contacts limit switch intermittently.	34.1 Zero board is defective.	34.1 Replace D1 or Q1.
	34.2 Inner limit switch is inserted too far into the bulkhead.	34.2 Back-out the inner limit switch.
	34.3 Open or shorted wires.	34.3 Check bulkhead harness assembly.
Dump Valve Problems		
35.0 Dump valve shorted and causes a short in board.	35.1 U15 is shorted out.	35.1 Replace U15.
36.0 Dump valve not working properly.	36.1 Poor pressure switch connection.	36.1 Press on terminals must be tight, check for switch actuation.
	36.2 Dump solenoid connector is defective.	36.2 Voltage across connector alternates from 12 to 0 VDC.
	36.3 Internal slide not moving freely in housing (old style mechanical dump valves only).	36.3 Check slide. Lightly sand the inside of the vent housing to remove any burrs or rough spots.
Oxygen Flow Problems		
37.0 FiO_2 less than desired, (A4 Alarm).	37.1 Oxygen source pressure to low or absent.	37.1 Check the O_2 source pressure. Must be greater than 45 psi.
	37.2 Oxygen proportioning valve malfunction.	37.2 Clean or replace oxygen inlet filter.
	37.3 Regulator malfunction.	37.3 Replace internal or external regulator.
38.0 FiO_2 more than desired, (A4 Alarm).	38.1 Oxygen source pressure too high.	38.1 Check O_2 source pressure. Must be less than 65 psi.
	38.2 Regulator malfunction.	38.2 Check output of regulator. Must be between 39 and 41 psi, flowing.

Troubleshooting Chart

Problem	Possible Cause	Action/Solution
38.0 Continued.	38.3 Proportioning valve malfunction.	38.3 Replace O_2 valve.
39.0 Tidal Volume less than desired.	39.1 Oxygen source pressure too low or absent.	39.1 Check O_2 source. Must be greater than 45 psi.
	39.2 Proportioning valve malfunction.	39.2 Replace oxygen valve.
	39.3 Regulator malfunction.	39.3 Check output of regulator. Must be 39 to 41 psi, flowing.
40.0 Tidal Volume more than desired.	40.1 Oxygen source pressure too high.	40.1 Check O_2 source pressure. Must be less than 65 psi.
	40.2 Proportioning valve malfunction.	40.2 Replace oxygen valve.
	40.3 Regulator malfunction.	40.3 Check output of regulator. Must be 39 to 41 psi, flowing.
41.0 SIMV spontaneous volume FiO_2 out of range.	41.1 Oxygen sensor malfunction.	41.1 Perform 2-point calibration of O_2 sensor. Sensor must be 6-17 mV at ambient.
	41.2 Oxygen thermistor malfunction.	41.2 Replace oxygen airway assembly.
42.0 Thermistor reading is above 130 (refer to step 3 of Calibration Steps in Section 10.0).	42.1 Thermistor assembly is not plugged to P3 on the logic board.	42.1 Check that the thermistor is plugged into P3 of the logic board.
	42.2 Thermistor assembly is open. This may be due to bad crimps at the connector, bad wires, or an open thermistor.	42.2 Unplug P3 and measure the resistance across the connector with the wires, not the logic board. If the resistance is infinite, the resistor, the wires, or the crimps in the connector are bad. Replace the oxygen airway assembly.
43.0 No oxygen flow.	43.1 R103 on O_2 control board is open.	43.1 Replace R103.
	43.2 Q102 is shorted open.	43.2 Replace Q102.
	43.3 U102 and CR101 on O_2 driver, (power board 37901 old style), are inoperative.	43.3 Replace U102 and CR101.

Problem	Possible Cause	Action/Solution
44.0 Oxygen valve is not operational.	44.1 Open Q101 on O_2 control board.	44.1 Replace Q101.
45.0 Unit auto cycles at -1.8 to 0 cm H_2O during oxygen test.	45.1 Zero reference solenoid inoperative.	45.1 Replace the zero reference solenoid.
46.0 Lack of O_2 delivery does not meet O_2 percentage.	46.1 U101 and Q101 are inoperative.	46.1 Replace U101 and Q101.
Error Codes		
47.0 A-5 Alarm.	47.1 Defective Q503 (FET) on power board.	47.1 Replace FET Q503.
48.0 A-5.3 Alarm.	48.1 Piston is contacting the inner limit switch because the switch is positioned too far into the bulkhead. There is no time for the piston to stop after reaching the zero point before contacting the inner limit switch.	48.1 Back-out inner limit switch.
	48.2 Outer limit switch improperly set.	48.2 Bend arm on outer limit switch until properly set.
	48.3 Zero board is defective.	48.3 Replace D1 and Q1 on the zero board.
	48.4 Loss of encoder signal due to improperly set encoder, or loose encoder wheel.	48.4 Check that the encoder wheel is properly positioned, and that the set-screw is tightened on the flat portion of the motor shaft.
49.0 Error code 5.9 is displayed.	49.1 U15 and U20 are defective.	49.1 Replace U15 and U20.
50.0 Unit displays 1.3 in volume window after start-up, (37992).	50.1 Microprocessor cannot access quadrature encoder, defective pal or defective quadrature encoder.	50.1 Troubleshoot the problem beginning with U10, U34, U13, and then U15.
51.0 Unit displays 1.1 in volume window after start-up.	51.1 U15 and U9 are shorted, (37902).	51.1 Replace U15 and U9.
52.0 Unit displays a 4.6 fault.	52.1 U5 Multiplexer is shorted.	52.1 Replace U5.
53.0 Unit displays 1.0 in volume window.	53.1 U20 defective, (37902).	53.1 Replace U20.

Troubleshooting Chart

Problem	Possible Cause	Action/Solution
53.0 Continued.	53.2 If capacitor auxiliary board is installed and the problem was not evident before that, then there may be a break in continuity at the feed through of the positive terminal of C9.	53.2 Check voltage at TP1 and TP7. If the voltages are out of spec, remove the capacitor auxiliary board and check for continuity at the positive feed through of C9 on the power board. If no continuity repair feed through with jumper wire.
	53.3 Poor solder connection under 10KμF capacitor on power board.	53.3 Repair solder connection
	53.4 Defective transducer.	53.4 Replace transducer.
	53.5 Defective zero reference solenoid.	53.5 Replace solenoid.
	53.6 Bad trace at C9 positive lead.	53.6 Repair trace.
54.0 Unit displays 2.0 in volume window at start-up.	54.1 Failure of the EPROM checksum.	54.1 Replace EPROM.
55.0 Unit displays 2.1 in volume window at start-up.	55.1 Failure of the NOVRAM.	55.1 Replace NOVRAM.
56.0 A4 alarm occurs randomly, even with O_2 off and disconnected.	56.1 Q1 may not be biased to deliver proper current, or may be defective.	56.1 Inspect U1 and Q1. Replace as necessary.
Miscellaneous Problems		
57.0 Unit repeats self diagnostic when subject to vibration.	57.1 Clock oscillator crystal has become dismounted inside the clock oscillator housing.	57.1 Replace clock oscillator U14 on the logic board.
58.0 Infinite resistance at 5 volt line.	58.1 5 volt line shorted to ground. D8 is shorted open.	58.1 Replace D8.
59.0 Rate slows down during operation.	59.1 Oscillator out of specs.	59.1 Replace oscillator.
60.0 During calibration all lights stay lit continuously.	60.1 U3, U15, U20, and U25 short out when heated, (37902).	60.1 Replace U3, U15, U20, and U25.
61.0 Unit does not run, constantly alarms, and clicking sound comes from power board.	61.1 U24 and U26 are shorted, (37902).	61.1 Replace U24 and U26.

Problem	Possible Cause	Action/Solution
62.0 Motor drive sluggish and rate drops.	62.1 U24 is shorted, damaging U15.	62.1 Repair short, replace U24 and U15.
63.0 Alarm circuit discharges alarm voltage.	63.1 Z1 in the alarm circuitry is shorted causing alarm voltage under 4.2 volts from TP5.	63.1 Replace Z1.
64.0 Relief valve is inoperative on test box.	64.1 Voltage at Pin 5 of the relay driver U3 drops when it should have risen.	64.1 Replace R513 switch.
65.0 8 volt analog and line voltage are incorrect.	65.1 Continuity break between the top and bottom pads of the positive lead of C9.	65.1 Install jumper wire to top and bottom of pad.
66.0 Raw voltage is not within specifications (18 to 23 volts).	66.1 Raw voltage is 1.4 volts at connector P1, Pin 35. There is a short in the 50-pin connector.	66.1 Replace 50-pin connector.
67.0 Unit blows 5 amp breaker after a few hours of run-in.	67.1 Gasket pad isolation faulty under U20.	67.1 Replace pad isolation.
68.0 Unit's PX1 voltage is not within specifications (1.30 to 1.40 volts).	68.1 Pressure transducer inoperative.	68.1 Replace transducer.
69.0 Anti-rotation hinge.	69.1 Hinge pins are too tight. 69.2 Hinge bent in the hinge knuckle.	69.1 Check the hinge for smooth operation. 69.2 Check the hinge eyelets for proper operation.

Troubleshooting Chart

(This page intentionally left blank)